

**Atty. Docket No.: 30293-1010**  
**Express Mail Label No.: EV 292297319 US**

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

**MULTI-AXIS WORKPIECE CHUCK**

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**MULTI-AXIS WORKPIECE CHUCK**

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**Field Of The Invention**

The invention generally relates to apparatus that holds a workpiece and orients it in different directions for cutting. More particularly, the invention concerns a chuck such as for  
10 holding a tissue specimen in a cutting device such as a microtome. The chuck can be rotated about at least two substantially perpendicular axes.

**Background Of The Invention**

Various forms of microtome chucks for retaining tissue workpieces for cutting are  
15 known. For example, known microtomes incorporate chucks that retain the tissue specimen block in a particular orientation for a cutting operation. In one example, the chuck moves relative to the blade while retaining the mounted tissue specimen in an otherwise fixed orientation.

One disadvantage of known microtome chucks is limitation on positioning the  
20 retained tissue specimen block. Where non-uniform tissue samples are provided this can require removal and manual reorientation of the tissue specimen block on the chuck in order to obtain a desired tissue section. This may result in waste of material as well.

Some known microtome chucks, if rotatable, are rotatable in one dimension only. Furthermore, if laboratory personnel desire to return the tissue chuck to an initial or previous  
25 position, it is difficult to return the tissue chuck exactly to the initial or previous position.

Another disadvantage of typical known microtome chucks is that a center of rotation for rotatable chucks is located at the chuck, which is a certain distance away from a cutting plane. This causes the tissue specimen to turn away from a cutting blade during adjustment of the tissue chuck.

5           Accordingly, there exists a need for a material workpiece chuck that is adjustable in multiple dimensions.

### **Summary Of The Invention**

The present invention alleviates to a great extent the disadvantages of the known  
10   tissue block chucks by providing a multi-axis workpiece chuck. In accordance with the present invention, the chuck provides a mounting assembly that retains a workpiece, such as a tissue specimen block in a substantially fixed orientation with respect to the chuck.

The chuck is motor-driven and is rotatable about at least two (2) axes. The chuck is preferably rotatable using a controller that is in communication with the motor(s). A  
15   user operates the controller. The user inputs a desired position for the chuck using the controller. One or more sensors may be used to sense a particular position of the chuck. According to one embodiment, each axis has three (3) sensors that detect a middle nominal position and end positions of the chuck. The user controls movement of the chuck using the controller that commands the motor to rotate the chuck to the desired  
20   position. The controller is in communication with the sensors and determines whether a particular position has been reached. The user may cause the motor to rotate the chuck until the particular position matches the desired position.

The chuck includes first and second portions that are rotatable about at least two orthogonal axes. The first portion rotates about a first axis and independently of the second portion. Rotation of the second portion about a second axis causes the first portion to rotate about the second axis also. This enables the chuck to be rotatable in multiple dimensions.

These and other features and advantages of the present invention will be appreciated from review of the following detailed description of the invention, along with the accompanying figures in which like reference numbers refer to like parts throughout.

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#### **Brief Description Of The Drawings**

FIG. 1 is a top/side view of a multi-axis chuck according to one embodiment of the invention;

FIG. 2 is a front/side view of a multi-axis chuck according to one embodiment of the invention;

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FIG. 3 is a schematic block diagram of a method for rotating a multi-axis chuck according to one embodiment of the invention.

#### **Detailed Description Of The Invention**

In the following paragraphs, the present invention will be described in detail by way of example with reference to the accompanying drawings. Throughout this description, the preferred embodiments and examples shown should be considered as exemplars, rather than as limitations on the present invention. As used herein, the "present invention" refers to any one of the embodiments of the invention described

herein, and any equivalents. Furthermore, reference to various aspects of the invention throughout this document does not mean that all claimed embodiments or methods must include the referenced aspects.

FIG. 1 illustrates a multi-axis chuck 10 according to one embodiment of the invention. The multi-axis chuck 10 includes mounting elements, namely a first portion 12, a second portion 14, and third portion 16. The front portion 12 includes a substrate receiving surface 18 and a cutting region 20.

A rear side of the first portion 12 is adjacent a front side of the second portion 14 and a rear side of the second portion 14 is adjacent a front side of the third portion 16. The substrate receiving surface 18 may be used to receive, for example, a tissue specimen. The multi-axis chuck may be used to maintain a tissue specimen on the substrate receiving surface 18 and within the cutting region 20 such that a slice of the tissue may be cut using known mechanisms for examination of the slice under a microscope. The substrate receiving surface 18 may be formed as a slot in the front portion 12. The substrate receiving surface 18 may receive a specimen holder 22.

The second portion 14 preferably includes a first degree scale 26 that indicates a number of degrees of rotation of the first portion 12 about a first axis of the cutting region 20. The first portion 12 preferably includes a first degree indicator 28. The first degree indicator 28 indicates on the first degree scale 26 the number of degrees of rotation of the first portion 12 about a first axis of the cutting region 20. According to one embodiment, the cutting region 20 consists of a point on or adjacent the cutting region 20 about which the multi-axis chuck 10 rotates.

A locking mechanism 30 may also be provided. The locking mechanism 30 may be used to lock the specimen holder 22 in the multi-axis chuck 10. After rotating the multi-axis chuck 10 using the controller (not shown), another locking mechanism may be engaged to lock the multi-axis chuck 10 in the desired position. This locking mechanism  
5 may be, for example, a permanent magnet solenoid, a geared motor or a rotating handle that causes the first, second, and third portions 12-16 to lock by friction or other known manner.

According to one embodiment, the first portion 12 rotates about a first axis of the cutting region 20 independent of the second portion 14 and the third portion 16. That is,  
10 the first portion 12 may be rotated without moving either the second portion 14 or the third portion 16. Additionally, when the second portion 14 is rotated about a second axis of the cutting region 20, this causes the first portion 12 to rotate in the same direction as the second portion 14. Preferably, the third portion 16 remains stationary.

The third portion 16 preferably includes a second degree scale 32 that indicates a  
15 number of degrees of rotation of the first portion 12 and the second portion 14 about a second axis of the cutting region 20. The second portion 14 preferably includes a second degree indicator 34. The second degree indicator 34 indicates on the second degree scale 32 a number of degrees of rotation of the first portion 12 and the second portion 14 about a second axis of the cutting region 20. Preferably, the second axis is perpendicular to the  
20 first axis.

According to one embodiment of the present invention, the first portion 12, the second portion 14, and the third portion 16 move relative to one another using protruding and recessed curved tracks 36a-36b, 38a-38b, respectively. Rear sides of the first portion

12 and the second portion 14 include protruding curved tracks 36a, 36b, respectively, that mate with recessed curved tracks 38a, 38b provided on the front sides of the second portion 14 and the third portion 16, respectively. The protruding curved track 36a is designed such that the first portion 12 may be rotated about the cutting region 20  
5 independently of the second and third portions 14, 16.

At least a portion of the protruding curved track 36a of the first portion 12 enters the recessed curved track 38b of the second portion 14. The protruding curved track 36a moves along the recessed curved track 38b to enable the first portion 12 to be rotated about a first axis of the cutting region 20. At least a portion of the protruding curved  
10 track 36a of the second portion 14 enters the recessed curved track 38b of the third portion 16. The protruding curved track 36a moves along the recessed curved track 38b to enable the second portion 14 to be rotated about a second axis of the cutting region 20. The second portion 14 and the first portion 12, however, are operatively coupled. Therefore, when the second portion 14 is rotated, this causes the first portion 12 to be  
15 rotated also. According to one embodiment of the present invention, the second axis is substantially perpendicular to the first axis.

FIG. 2 is a front/side view of the multi-axis chuck 10 shown in FIG. 1. FIG. 2 illustrates a controller 42, sensors 44a, 44b, and motors 46a, 46b that may be used to rotate the multi-axis chuck 10. According to one embodiment, the sensors 44a, 44b each  
20 include three (3) separate sensors that are used to sense extreme and center positions of the multi-axis chuck 10. The motors 46a, 46b are in communication with the controller 42 and the sensors 44a, 44b. The sensors 44a, 44b are operatively connected to the motors 46a, 46b, respectively. The sensor 44a and corresponding motor 46a are

operatively connected to the first portion 12. The sensor 44a is used to sense a position of the first portion 12. The motor 46a is used to rotate the first portion 12 about the first axis to a position desired by a user. The sensor 44b is used to sense a position of the first portion and the second portion 14. The motor 46b is used to rotate the first portion 12 and the second portion 14 about the second axis to a position desired by the user. According to one embodiment, the multi-axis chuck 10 includes two motors that each control rotation of the multi-axis chuck 10 about one of the first axis and the second axis. Preferably, three (3) sensors are provided along each of the first axis and the second axis for sensing the position of the multi-axis chuck 10 about the first axis and the second axis.

According to one embodiment, the controller 42 may store a zero position of the multi-axis chuck 10. The zero position may be, for example, a home or initial position in which the first portion 12 and the second portion 12 of the multi-axis chuck 10 are positioned at a most common or starting position. The starting position may be, for example, when the first portion 12 and the second portion 14 are positioned at zero degrees of rotation from the cutting region 20. The zero position may be based on a number of degrees of rotation about the first and second axes.

According to another embodiment, the controller 42 may store a plurality of positions in a memory of the controller 42 such that a user may quickly position the multi-axis chuck 10. The motor(s) may include an encoder that enables the controller 42 to identify a position of the multi-axis chuck 10 and the user to store a plurality of positions of the multi-axis chuck 10 for quickly positioning the multi-axis chuck 10 in a particular position. The user may retrieve a stored position from the controller memory



using, for example, a selectable menu. For example, if a user determines that a position of two (2) degrees of rotation about the first axis of the first portion 12 and six (6) degrees of rotation about the second axis of the first portion 12 and the second portion 14 is most frequently used, the user may store this position in the controller 42.

5           This position may be recalled by, for example, assigning a shortcut key to the position and, possibly, assigning a name to the shortcut key. For example, if the controller 42 includes a conventional computer keyboard, an F1 function key may be assigned as the zero position where the first portion 12 and the second portion 14 are at zero degrees of rotation about the first axis and the second axis and an F2 function key  
10   may be assigned as a commonly used position shortcut key. Alternatively, a combination of keys or a numeric key input may be used. For example, a Shift-Z key combination may be used as the zero position shortcut key and an input of 12 may be used as the commonly used position shortcut key.

          According to one embodiment, the controller may also store extreme positions of  
15   the multi-axis chuck. For example, the controller may store a maximum degree of rotation of the first portion about the first axis and a maximum degree of rotation of the first portion and the second portion about the second axis. These extreme positions may also be assigned as shortcut keys such that a user may quickly position the portions in these extreme positions.

20           A user of the multi-axis chuck 10 may use the controller 42 to position the multi-axis chuck 10 in a desired position. The desired position may be input using, for example, a joystick controller, four-way keypad or particular degrees of rotation about a predetermined axis using a keypad of a processor. The user may use the controller 42 to

rotate the first portion 12 and/or the first portion 12 and the second portion 14. The user may initiate rotation of the portion(s) 12, 14 by moving a joystick such that the portion(s) 12, 14 rotate toward a desired position.

Alternatively, the user may input a number of degrees to rotate the portion(s)  
5 about the cutting region 20 using a numeric keypad in communication with the controller 42. The number of degrees of rotation may correspond to a number on the first degree scale 26, the second degree scale 32, or both. For example, the user may input into the controller 42 a three (3) degree clockwise rotation for the first portion 12 along the first degree scale 26 and a five (5) degree counter-clockwise rotation for the first portion 12  
10 and the second portion 14 along the second degree scale 32. According to one embodiment, the user may also rotate the portion(s) 12, 14 using directional keys, for example, arrow keys, on a keyboard in communication with the controller 42. The user may, for example, press and hold an arrow key until the portion(s) are in a desired position.

15 FIG. 3 illustrates a method for rotating a multi-axis chuck according to one embodiment of the present invention. A rotate signal is received by a controller, step 102. The multi-axis chuck is rotated from a first position to a second position, step 104. The controller determines whether the second position matches a desired position input by a user using the controller, step 106. If a determination is made that the second  
20 position does not match the desired position, the multi-axis chuck may be rotated, step 104. The steps of rotating and determining may be repeated until the second position matches the desired position. After a determination is made that the second position matches the desired position, the multi-axis chuck stops rotating, step 108.

According to one embodiment, the controller may record a predetermined number of positions where the multi-axis chuck stopped. This may be used to repeat the previous positions in which the multi-axis chuck stopped. For example, if a user determines that a sequence of positions of the multi-axis chuck assists in obtaining preferred tissue specimens, the user may instruct the controller to repeat the sequence of positions. This may be done, for example, by having the controller automatically record the sequence of positions where the multi-axis chuck stops, indicating a start position and a stop position by inputting a command into the controller at the start and stop positions, etc.

Thus, it is seen that a multi-axis chuck is provided. One skilled in the art will appreciate that the present invention can be practiced by other than the preferred embodiments which are presented in this description for purposes of illustration and not of limitation, and the present invention is limited only by the claims that follow. It is noted that equivalents for the particular embodiments discussed in this description may practice the invention as well.

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### **Industrial Applicability**

The multi-axis chuck of the present invention may be used in a variety of applications. For example, the multi-axis chuck may be used in combination with a bench-top microtome. The multi-axis chuck may be used to position a tissue specimen in a desired position and at a desired angle such that a microtome may be used to evenly and finely slice a portion of the tissue.

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The multi-axis chuck may also be used with a cryostat. The multi-axis chuck may be located in a cryostat for positioning tissue specimens that need to be

maintained in a refrigerated state of -20 degrees Celsius or below. The multi-axis chuck may be used to better position the tissue specimen for obtaining an even and finely sliced portion of the tissue specimen.

The multi-axis chuck may also enable a previously sectioned block to be re-  
5 sectioned at substantially the same angle as before. This is due to a memory location compatibility of the controller and position feedback.